Citation:

Mourao DM, Bressan J, Campbell WW, Mattes RD. Effects of food form on appetite and energy intake in lean and obese young adults. *Int J Obes* (Lond). 2007 Nov;31(11):1688-95. Epub 2007 Jun 19.

PubMed ID: 17579632

Study Design:

non-randomized group trial

Class:

C - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To contrast the appetitive and acute compensatory dietary responses of lean and obese adults presented with comparable solid and beverage forms of high carbohydrate, high fat, or high protein foods.

Inclusion Criteria:

- BMI between 18 - 23 or 30 - 35 kg/m^2
- Age 18 - 50 years
- ≤ 3 kg weight change within the past 3 months
- not taking medication known to influence appetite
- regular consumer of breakfast and lunch (self-reported)
- non-restrained eater (score <14 on the three factor eating questionnaire)
- non-smoker.

Exclusion Criteria:

- Individuals <18 years old and >50 years old
- BMI <18, between 23.1 and 29.9, and >35 kg/m^2
- ≥ 3 kg weight changes within the past 3 months
- Taking medication known to influence appetite
- Not a regular consumer of breakfast and lunch (self-reported)
- Restrained eater (score >14 on the three factor eating questionnaire)
- Smoker.

Description of Study Protocol:

Recruitment

Individuals were recruited by public advertisement, completed and signed an informed consent for approved by the Purdue University IRB, and received monetary compensation.

Design

Non-randomized group crossover trial

Intervention (if applicable)

120 Participants (60 lean, 60 obese) were challenged with matched beverage and solid food forms of high carbohydrate, high protein, and high fat foods. Forty different participants (N = 20 lean and 20 obese) were tested with each of the food systems. Each participant came to the lab on three test days (control, beverage, and solid). Participants were instructed to fast for 10 h overnight, eat their typical breakfast (same meal for each of the 3 test days), and fast again for at least 3 h before lunch. A finger stick glucose measurement was taken to verify pre-test fast was maintained (blood glucose <110 mg/dl). Testing visits were scheduled during participants' usual lunchtimes. At lunchtime participants were provided with chicken sandwiches ad libitum and water (control session) or chicken sandwiches ad libitum and sample foods. On test days with the sample foods mentioned, participants were instructed to eat two-thirds of the sample food, evaluate their level of fullness, and determine if eating a chicken sandwich would impede their ability to finish consuming the sample food. Pre- and post-meal, participants completed a motor skills test and an appetite questionnaire. Participants kept a food record of all food and beverages consumed until the end of the test day, as well as completing the appetite questionnaire via Personal Digital Assistant each hour until the end of the test day.

Statistical Analysis

Repeated measures analysis of variance with one within - subject factor (meal form - beverage and solid) and one between-subject factor (lean vs obese). 20 participants per group (lean vs obese) needed for 80% power.

Data Collection Summary:

Timing of Measurements

Testing visits were scheduled during participants' usual lunchtimes. On test days participants kept a food record of all foods and beverages consumed before going to sleep and completed an appetite questionnaire on a PDA (given to them) each hour until going to sleep.

Dependent Variables

- Discretionary energy consumed at lunch
- Energy consumed after lunch
- Post-breakfast energy intake: sum of energy consumed at lunch and energy consumed after lunch
- Satiety: energy content of the first post-lunch meal and interval between lunch and first eating occasionof > 150 kcal)
- Dietary compensation (total day)
- Appetite ratings.

Independent Variables

- For the high protein food samples:
    - Beverage - Fat-free, low carbohydrate milk; Solid- cheese fortified with whey to a concentration comparable to the milk
- For the high carbohydrate food samples:
    - Beverage - watermelon juice; Solid - watermelon fruit
- For the high fat food samples:
    - Beverage - coconut milk; Solid - fresh coconut meat. Water (1:1) and 1 tsp of Equal sweetener were added to the coconut milk to match the sweetness of the meat ; the formulation was developed and pilot tested before the study.
- The lean participants were provided 125 kcal of test food and the obese participants were provided 225 kcal of test food.

Control Variables

- Participants were instructed in portion size estimation using NASCO food models and true-size pictures with a PowerPoint presentation.
- The metabolic challenges were different for the lean and obese groups; participants in the lean group received a 125 kcal load while the obese group received a 225 kcal load. These loads provided each group with comparable challenges and volumes, each being 5 - 10 percent of their estimated energy requirement.
- Participants completed a motor skills test upon arrival at the lab for lunch and drew a single geometric form in the PDA every other hour until going to sleep; they were informed of the researcher's interest in the association between appetite and fine motor skills as a way to deemphasize the focus on ingestive behavior.

Description of Actual Data Sample:

Initial N: 120 lean (N=60) and obese (N=60) participants

Attrition (final N): none mentioned

Age: 18 - 50 years

Ethnicity: not specified

Anthropometrics:

Participants in the lean group had a BMI between 18 - 23 kg/m^2, while participants in the obese group had a BMI between 30 - 35 kg/m^2.

Location: Indiana, United States

Summary of Results:

Key Findings

Summary of Key Findings:

- The beverage form of all three groups resulted in statistically significant reverse compensation, meaning that daily calorie intake was greater than baseline by an amount that

exceeded the calories in the beverage. In comparison, there was partial to overcompensation for the solid foods, meaning that calorie intake was lower than baseline.
- Regardless of the predominant energy source, the beverage form elicited a weaker compensatory dietary response than the matched solid food form. Thus, total daily energy intake was significantly higher by 12.4, 19 and 15% on days the beverage forms of the high-carbohydrate, -fat and -protein foods were ingested, respectively.
- Differences between lean and obese participants were small and not systematic.

Variables	Dietary Compensation (total day) (%)	Statistical Significance
High Protein	127 ± 58	P=0.029
Solid	- 54 ± 102	
Beverage		
High Carbohydrate	152 ± 52	P=0.006
Solid	- 8 ± 77	
Beverage		
High Fat	42 ± 48	P=0.016
Solid	- 179 ± 97	
Beverage		

Author Conclusion:

Calorie intake for the whole day was significantly greater for all three groups (high protein, high carbohydrate, and high fat) when the beverage form of the food was consumed in a lunch meal, compared with the solid form of the food. The beverage form of all three groups resulted in reverse compensation, meaning that daily calorie intake was greater than baseline by an amount that exceeded the calories in the beverage. In comparison, there was partial to overcompensation for the solid foods, meaning that calorie intake was lower than baseline. There was no clear indication that this differs between lean and obese individuals. Because having high protein, high carbohydrate, and high fat beverages with lunch all led to consuming more calories than would be consumed on a typical day, efforts to moderate energy intake should consider the contribution of all types of beverages.

Reviewer Comments:

A major limitation of this study is its small sample size and its exclusion of participants with a BMI between 23.1 and 29.9 kg/m^2, as well as those with a BMI greater than 35 kg/m^2. The small sample size and exclusion factors limits the generalizability of these results. In addition, dietary compensation was only observed for one day, and daily intake is highly variable. Another limitation is that only three foods were tested, and these foods do not represent all facets of products and their modulating affect on consumption.

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes

Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	No
3.	**Were study groups comparable?**	???
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	No
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	???
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes

3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	N/A
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	N/A
4.1.	Were follow-up methods described and the same for all groups?	N/A
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	N/A
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	N/A
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	No
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	No
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	No
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	N/A
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	N/A

6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	Yes
6.6.	Were extra or unplanned treatments described?	No
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	???
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes

	8.7.	If negative findings, was a power calculation reported to address type 2 error?	Yes
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**		Yes
	9.1.	Is there a discussion of findings?	Yes
	9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**		Yes
	10.1.	Were sources of funding and investigators' affiliations described?	Yes
	10.2.	Was the study free from apparent conflict of interest?	Yes